www.zyvex.com

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ATP Advisory Committee
Nanotechnology without the Hype

Overview

- Corporate Overview
- Strategic Thrust
- Products and Capabilities Overview
- Open Discussion

Our Mission

To be the the leading worldwide supplier of tools, products, and services that enable adaptable, affordable, and molecularly precise manufacturing.

Corporate Introduction

- Privately held company
- Founded in 1997
- Located in Richardson, Texas
- Detailed Five-Year Strategic Business and Marketing plans
- Detailed Technology Roadmap
- Aggressive IP strategy
- Extensive list of scientific and business publications

Resources

- Headcount: 52 and increasing
  - 17 Ph.D.s
  - Engineers, scientists, technical management
- 44,000 sq. ft. facility
- Class 100 clean room
- Several fully equipped laboratories
- CNC-equipped machine shop
- Equipment: SEM, TEM, AFM, SPM, UHV STM, numerous lasers, MEMS motion analyzer, electrical testing station

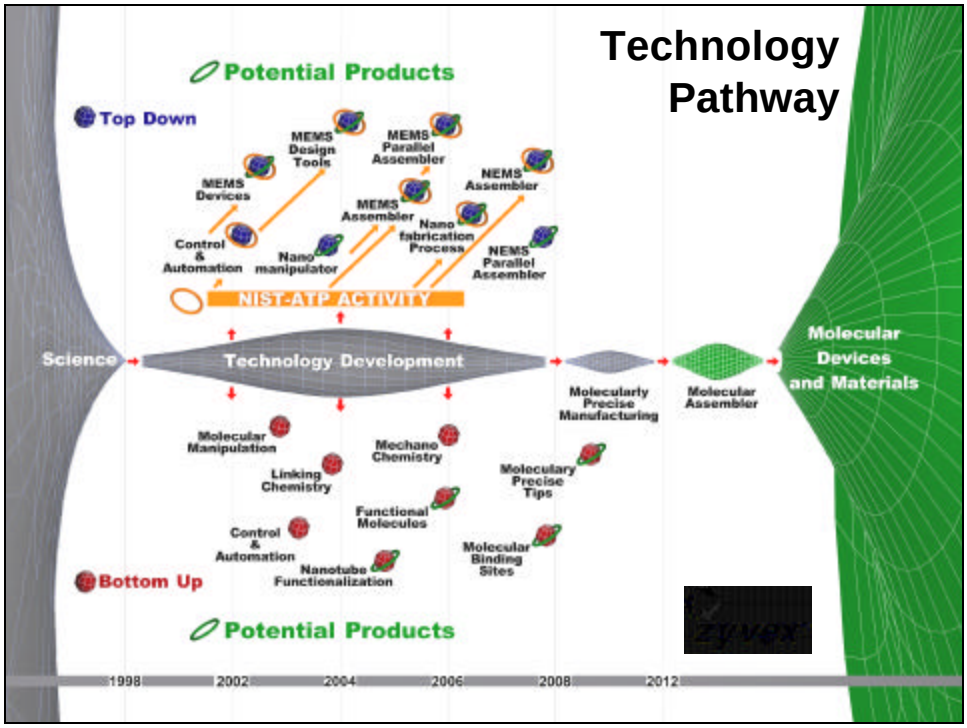
Nanotechnology *vs.* Molecular Nanotechnology

Nanotechnology

- Describes anything with characteristic dimensions at the nanometer (one billionth of a meter) scale.

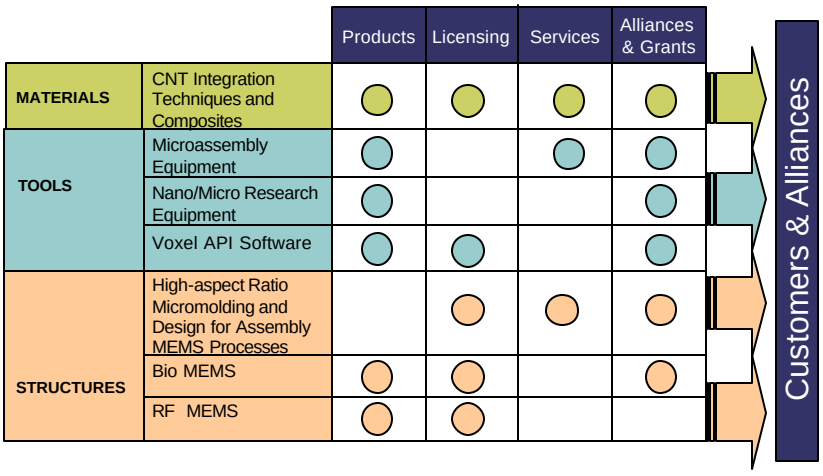
Molecular Nanotechnology (MNT)

- Use of a controlled sequence of nanopositioning to perform mechanochemistry at exactly the reaction sites desired, flexibly manufacturing atomically precise products under software control.



Technology Platform Approach

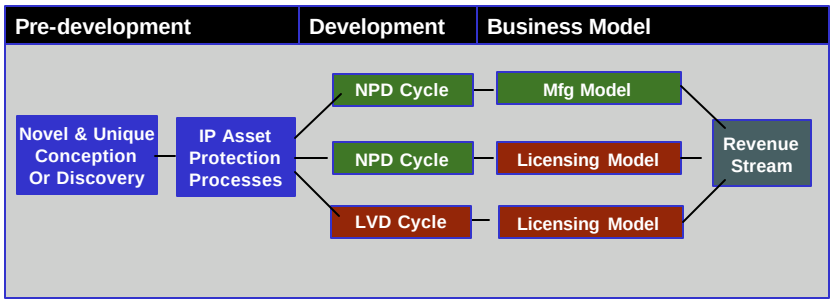
Solutions Matrix



Stages of Growth

- **Stage One**
  - Develop technology
- **Stage Two**
  - Secure patents
- **Stage Three**
  - Market-driven product & licensing development
- **Stage Four**
  - Customer sales and licensing

Development Modes



Note:
NPD = New Product Development
LVD = Licensing Vehicle Development

Customers

Partial List

Alliances

Partial List

FROST & SULLIVAN

KEITHLEY

CARBON NANOTECHNOLOGIES INCORPORATED

RICE UNIVERSITY

Kellogg School of Management

COVENTOR

THE UNIVERSITY OF TEXAS AT AUSTIN

Rensselaer

PENNSTATE

UTD

MIT Sloan MANAGEMENT

UNIVERSITY of NORTH TEXAS

University of Colorado System CAMPmode

BSAC Berkeley Sensor & Actuator Center

NORTHWESTERN UNIVERSITY

HARVARD BUSINESS SCHOOL

Press

Partial List

SCIENTIFIC AMERICAN

Forbes

TLC LIFE UNSCRIPTED

Discovery CHANNEL

NATIONAL GEOGRAPHIC

USA TODAY

The New York Times

electronic design

HISTORY CHANNEL .COM THE BEST SEARCH IN HISTORY

smalltimes BIG NEWS IN SMALL TECH.

IEEE SPECTRUM

Dallas Business Journal

D

The Dallas Morning News

Dallas-Fort Worth TechBiz

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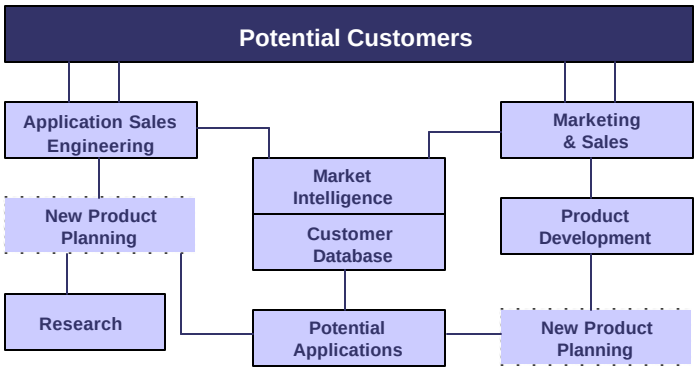
Stages of Growth



Intellectual Property

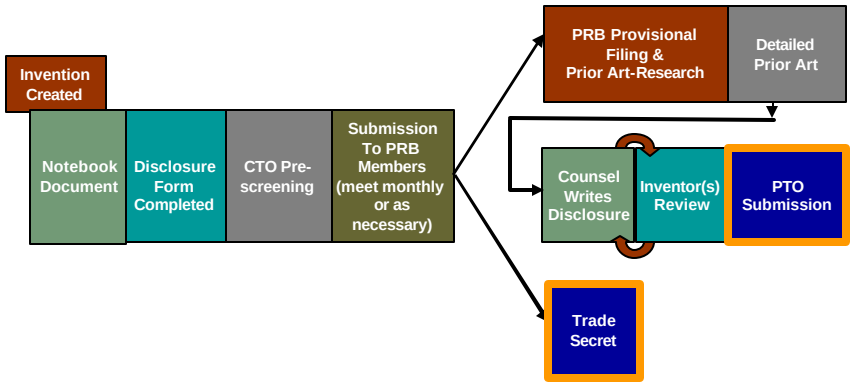
Zyvex patents

- 5 patents issued
- 43 patents pending
- 1 notification of allowance

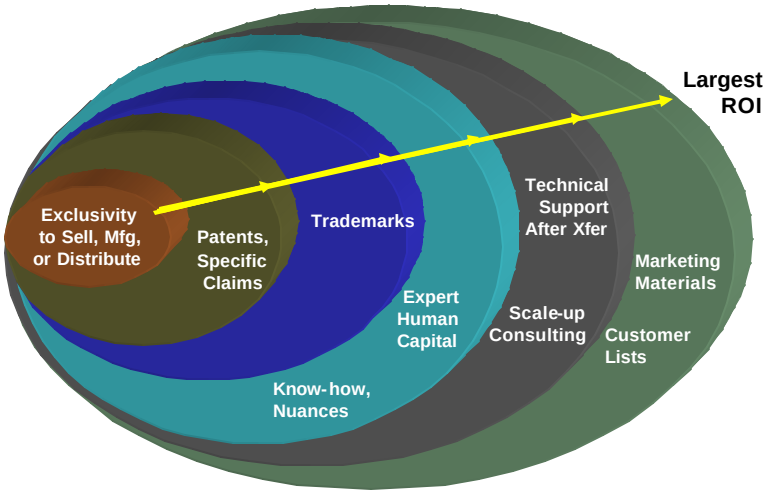
Categories

- Molecular nanotechnology
- Microassembly technology
- Nanostructure process techniques
- Micro- and nanodevices
- Microconnector technology

Patent Filing Process



The Saleable IP Package

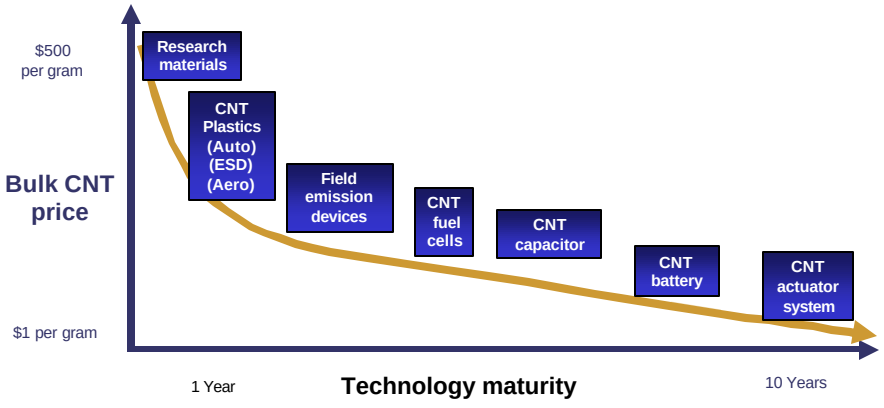


The Zyvex Approach: Materials

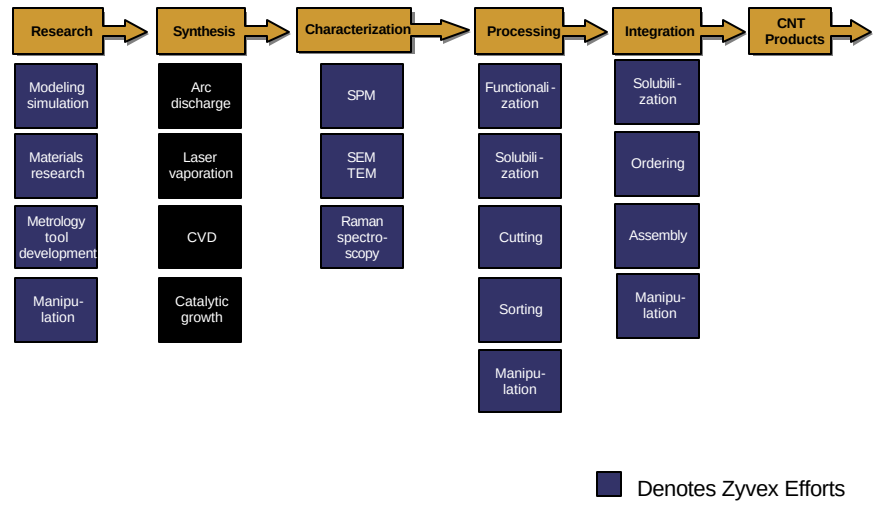
Development Goals

- Develop affordable, scalable, and superior CNT processing technologies
- Screen and develop practical CNT applications based on our CNT processing technologies

CNT Commercialization Map



CNT Value Chain



Nanotube Research Competence and IP Assets

External Endorsement & Support

- Prestigious NASA-funded research contract intended for achieving structurally-superior materials based on Zyvex proprietary CNT functionalization techniques.
- Customer-funded development for specific applications .

Key CNT Publications: November 2000 – present

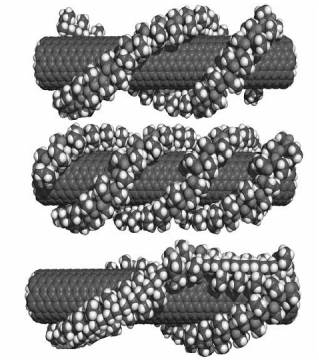
- "Cyclodextrin-Mediated Soft Cutting of Single-Walled Carbon Nanotubes." *J. Am. Chem. Soc.*, 123, 6201-6202 (2001).
- "'Soft' way to cut nanotubes." *Chem. & Eng. News*, 79 (July 2, 2001), p. 23.
- "Room-Temperature Assembly of Directional Carbon Nanotube Strings." *J. Am. Chem. Soc.*, 124, 758-759 (2002).
- "Noncovalent Engineering of Carbon Nanotube Surfaces by Rigid Functional Conjugated Polymers." *J. Am. Chem. Soc.*, 124, 9034-9035 (2002).

Key CNT Intellectual Property

- Several U.S. Patents filed with international foreign rights secured.

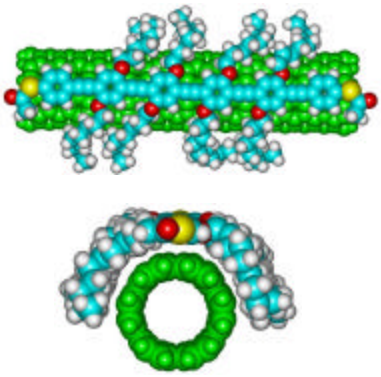
Approaches of CNT Integration

[Other approaches]



Polymer Wrapping
(covalent-engineering)

[Zyvex Corporation]



Polymer Non-Wrapping
(non-covalent engineering)

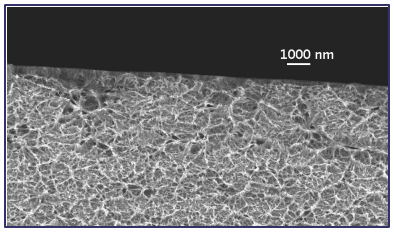
CNT-Surface Solubility Engineering

Demonstrations

- A high yield non-covalent (low energy) process
- Allows increased functionality without loss of CNT properties

Applications

- Prerequisite for efficient CNT integration
- Electroless coating / EMI shield coating
- FED
- Highly dispersed nanotube / ceramic composites
- Highly dispersed nanotube / epoxy composites
- Highly dispersed nanotube / polymer composites



Cross-Section of 3% Wt. CNT Polycarbonate

Polymer-Non-Wrapping *vs.* Polymer-Wrapping

Functionalization of CNTs

Key Attributes	Polymer-Non-Wrapping [redacted]	Polymer-Wrapping (Competitors)
Quantitative yield	High	High
CNT damage or loss of properties	No damage, No property loss	Surface Damaging, Carbon loss
Suitability for all SWNTs and MWNTs	Yes	Unsuitable for HiPco-SWNTs
Organic solubization for HiPco-SWNTs	> 50x Higher than competition	
Control of functional positions	Superior	Low control
Functionalization options	Highly versatile	Non-versatile

Polymer Composites

Accomplishments

- Double the strength of pure polymers
- 5 times increase in strain handling
- 1000 times greater conductivity than best published results of others

Goal: Better – Faster- Cheaper

Technology Comparison

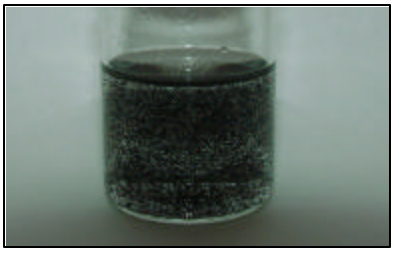
View through 1mm of suspension of CNTs vs our solution of CNTs

- Our technology produces excellent dispersion in organic solvents.
- Compare the large visible clumps of CNTs visible in standard suspensions of CNTs with our solutions.
- We have produced CNT/polymer composites using this technology.

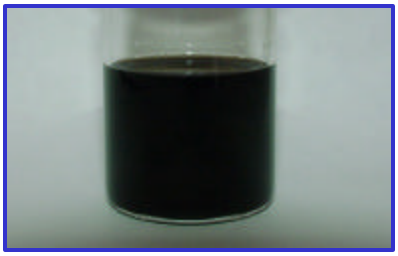
Suspension of 5 mg SWNT in 10 ml Organic Solvent

5 mg SWNT in 10 ml Chloroform using Zyvex Technology

Technology Comparison

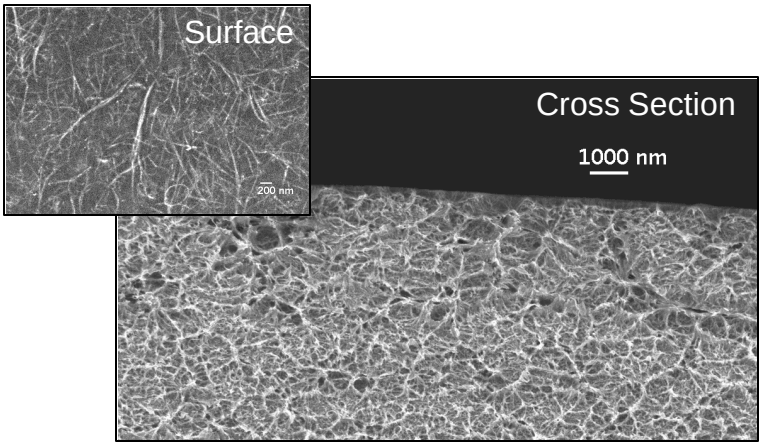


Suspension of SWNT in Organic Solvent



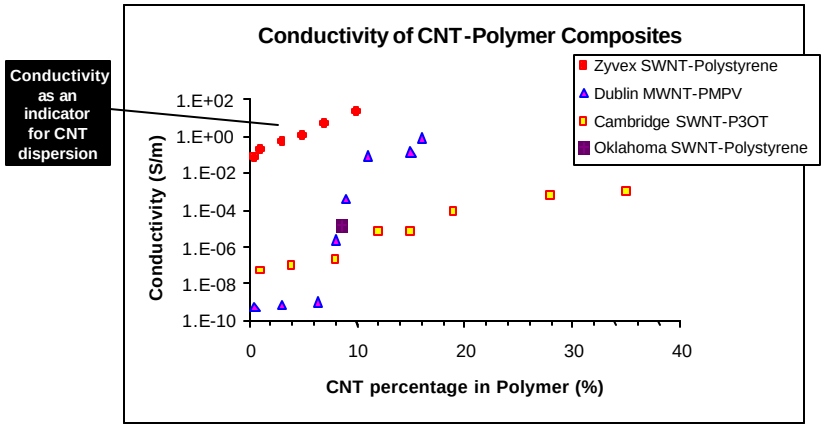
Suspended in Chloroform using Zyvex Technology

Zyvex CNT Dispersion

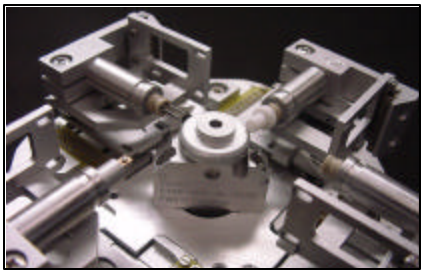


SWNTs (5 wt%)/Polystyrene Composites

Electrical Conductivity



Dispersed SWNTs significantly increase the electrical conductivity.



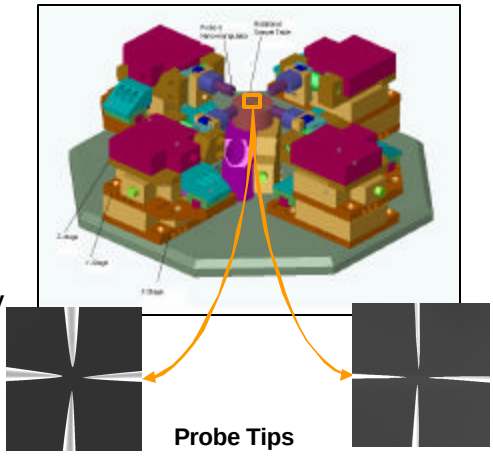
The Zyvex Approach: Tools

SEM Nanomanipulator

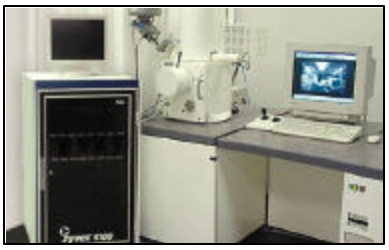
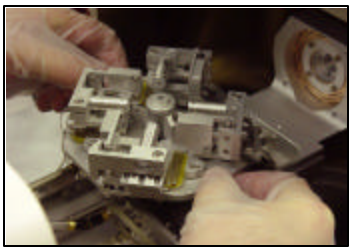
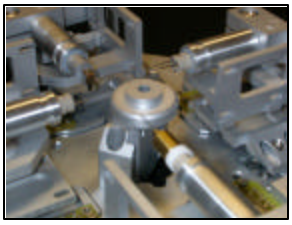
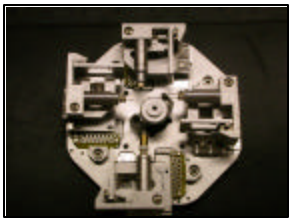
Key Features
- Comprised of one platform and task-focused end-effectors
- 4 points of manipulation and characterization
- Compact / modular design
- Accommodates most SEM stations
- Quick-change of end-effectors

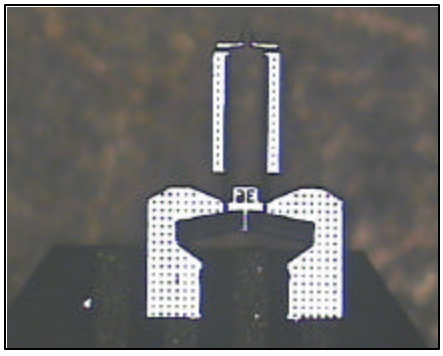
Under development
- Several end-effectors for increased tool functionality
- Compatibility/ Interchangeability w/ TEM
- 6 points of manipulation
- MEMS-actuator technology

Applications
- Electrical measurements
- Mechanical measurements
- Assembly and manipulation



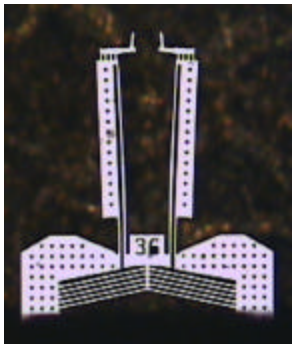
S100 Nanomanipulator System



The Zyvex Approach: Structures

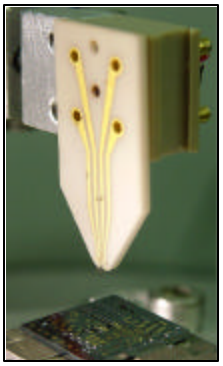
Microgrippers



Microgripper with 36 µm opening

Patent 6,398,280

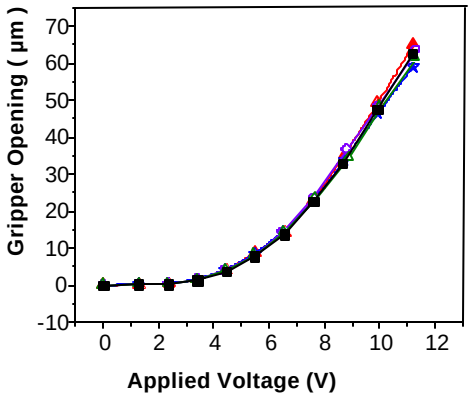
Microgrippers



Mounted to a manipulation station

Opening vs. Applied Voltage

Gripper opening with respect to the power-off position calculated as displacement of left arm + displacement of right arm



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